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ABSTRACT

This study attempts to appraise the effectiveness of chronic heavy exercise on 13 male swimmers from 10 to 17 years of age. The experimental group trained six days a week, often with more than one workout per day. During this period, the principles of interval training were employed in conjunction with high-intensity swimming. At the completion of training, each subject rode a bicycle ergometer at 60 revolutions per minute, with varying workloads, in order to test maximal aerobic capacity. The maximal oxygen consumption test consisted of three exercise periods, each four minutes long, with a recovery time between exercise periods of ten minutes. On the basis of the data obtained from the investigation, it was concluded that age-group swimmers possess significantly higher aerobic power than untrained males of the same age. In addition, it is felt that due to chronic heavy physical training, this high level of cardiovascular fitness is maintained throughout the entire training year. (JS)

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METABOLIC EFFECTS OF CHRONIC HEAVY PHYSICAL TRAINING ON MALE AGE GROUP SWIMMERS. Garret P. Caffrey, University of Denver; Robert L. Bartels and Thomas E. Shaffer, The Ohio State University; Pamela S. Robinson, University of North Carolina.

Of the estimated one and one half to two million competitive swimmers now in active training in the United States, many are members of the popular and fast growing age group swimming programs. During this swimming growth period the basic training programs used have dramatically changed. Some of these new innovations that have evolved are: (1) the use of interval training in the preparation of swimmers for competition, (2) a great increase in total training distances per average training day, and (3) an increase in the average number of workouts per week across a training year.

With such a vast number of swimmers undergoing high intensity training in the form of chronic heavy exercise at such an early age, an investigation was needed to examine the resulting physiological effects. Due to the success of outstanding swimmers using these vigorous training programs, it is often assumed beneficial for all participants. However, as yet this has not been substantiated by relevant research. It was the specific purpose of this study to scientifically appraise the effectiveness of such a training program on thirteen male age group swimmers from 10 to 17 years of age.

The experimental group consisted of 13 trained males chosen from the Upper Arlington Ohio Swim Club. Thirteen male students from the public schools in Upper Arlington, Ohio, were selected for the control group based on age, ponderal index and body surface area. Members of this control group did not actively train in cross country, swimming or highly aerobic activities. The experimental group trained six days a week, with more than one workout per day not uncommon. The principles of interval training were employed in conjunction with high intensity swimming. Total distances approaching 12,000 meters were periodically covered in one day.

All subjects underwent a pre-test consisting of physical examination, hand-wrist X-rays to determine skeletal maturation and an orientation to the bicycle ergometer in the Exercise Physiology Research Laboratory at The Ohio State University.

During measurement of maximal aerobic capacity, the subject rode a Jacquet Universal Bicycle Ergometer at 60 revolutions per minute with varying workloads. The maximal oxygen consumption test consisted of three exercise periods, each 4 minutes in duration. These exercise periods were designed with progressive increases in workload to achieve maximal oxygen consumption during the last ride. Initial wattage on the bicycle ergometer for the first exercise period was determined on the basis of heart rate achieved during the orientation practice ride. Recovery time between exercise periods was 10 minutes. The subject recovered sitting in a chair adjacent to the bicycle ergometer. Oxygen consumption was measured by the open circuit method.

A forearm venous blood sample was taken 5 minutes after exercise. The sample was immediately deproteinized by perchl~racetic acid and refrigerated. Analysis of lactic acid concentration was performed by the colorimetric method. Using three leads from a Hewlett-Packard electrocardiograph heart rate was monitored during the rest, exercise and recovery periods. Maximal pulmonary ventilation ATPS during the highest minute of oxygen consumption was read and recorded directly from a Cowan CD-4 gas meter. The volume was then converted to maximal pulmonary ventilation BTPS.

Energy derived from the anaerobic energy sources was calculated individually from the data collected during the maximal aerobic tests. Oxygen consumed during the first two minutes of recovery above the normal resting value for the same time period was considered the alactacid oxygen debt. The caloric equivalent of one liter of oxygen was assumed to be 5 kilocalories. Blood lactic acid concentration following exercise was used to calculate total body lactic acid production. Caloric equivalent of one gram of lactic acid was considered to be 0.222 kilocalories.

The lack of statistical change in maximal oxygen consumption exhibited by the experimental group after training reveals the considerable adaptation of the oxygen transport system maintained by these age group swimmers throughout their year-round training program. At the time of the pre-training period evaluation, the swimmers had recently finished a very intensive summer training program. It should be mentioned that the chronic exercise engaged in by these age group swimmers has caused adaptation of the oxygen transport system, as revealed by maximal oxygen consumption, to near peak levels. However, this continued training appears to give the swimmers the ability to come closer to this maximal level of oxygen consumption during swimming and to maintain this level for a greater period of time. The slight increase in maximal osygen uptake experienced by the experimental group after the training period can probably be attributed to growth, since aerobic capacity does not peak until approximately age 20. The highly significant ($p < .001$) 20 percent difference in maximal oxygen uptake (ml/Kg-min) between the swimmers and the control group ($56.0 \pm 6.6$ vs. $46.2 \pm 4.0$ and $57.4 \pm 5.3$ vs. $48.5 \pm 4.0$) may be due in part to heredity but most of the difference is accountable to the adaptation of the oxygen transport system as a result of the chronic heavy physical training engaged in year after year by the experimental group.

Before the training time period began the experimental and control groups were not statistically different in alactacid capacity. However, after the intensive training program undertaken by the experimental group significant ($p < .02$) differences did appear. It seems a possibility that even though maximal aerobic capacity appears relatively stable throughout the training year, maximal alactacid capacity may peak toward the end of the training season. This would be a highly desirable outcome since most age group training is geared toward the final championship meets. This is further substantiated by the fact that respiration is

not as free as in other physical activities and must be synchronized with the swimming strokes. Since the oxygen transport system is impaired the swimmer must depend more on anaerobic processes to produce the required energy. In addition, a large oxygen debt and high blood lactate levels are common to swimmers after a race.

The experimental swimming group exceeded the control group in net blood lactic acid concentration (mg/100 ml blood) by roughly 20 percent both before and after the training time period. Significance was prevented by the considerable variance of lactic acid values due to the wide range of ages of the subject.

Since maximal pulmonary ventilation (l/min BTPS) is highly correlated with maximal oxygen consumption (l/min) results concerning these two variables are similar. No significant difference was found between the pre-training period and post-training period means in pulmonary ventilation for either the experimental or control group. However, as in maximal oxygen uptake, the swimming group exceeded the control group significantly ($p < .05$) both before ($113.2 \pm 40.2$ vs. $85.9 \pm 27.9$) and after ($113.3 \pm 38.3$ vs. $85.3 \pm 23.1$) the training time period.

On the basis of the data obtained from this investigation, it was concluded that these age group swimmers possess significantly higher aerobic power than untrained males of the same age. In addition, it is felt that due to chronic heavy physical training this high level of cardiovascular fitness is maintained throughout the entire training year.